Case Study 232

Variable speed drives for wood dust extract fans

Ducal's showroom

Case Study Objectives

To demonstrate the energy savings which can be achieved by installing variable speed drive systems on dust extraction fans.

Potential Users

Any machining company where waste or dust is removed by air extraction. The greatest savings will be achieved by factories operating in a batch production mode or with spare machine capacity.

Investment Cost

£9,000 (1993 prices)

Savings Achieved

118,800 kWh/year (428 GJ/year), worth £5,800/year (1993 prices)

Payback Period

1.6 years

Case Study Summary

Ducal is the largest manufacturer of quality solid pine furniture in Europe. Their wood mill at Andover processes between 300 and 400 cubic metres of timber each week, thereby generating large quantities of waste. This waste is removed by eight extractor fans, each driven by a 30 kW motor, handling chippings and dust from 28 machines. Prior to modification, dust extraction accounted for 40-45% of the electrical power consumed at the mill.

Extraction systems are designed to cope with the maximum volume of waste that can be produced by a factory's machines at any one time. However, most factories, even when working at maximum capacity, do not require all machines to be operating continuously. Matching fan speed to work load can therefore reduce energy consumption.

Ducal installed variable speed drives to provide automatic control of the extractor fans in their factory. Even with factory loading at a high level, this modification has reduced energy consumption by 42% and improved the working environment for employees. At normal usage levels, with more idle time on machines, the savings would be even greater.

Host Organisation

Ducal Limited
Walworth Road
Andover
SP10 5AZ

Equipment Supplier

Telemecanique Ltd
University of Warwick Science Park
Sir William Lyons Road
Coventry
CV4 7EZ
Tel No 01203 416255
Mr A Hodson/Mr V Murray

Monitoring Organisation

The Dyer Warner Partnership
Cliffe House
Church Hill
Birstall
Leicester
LE4 4DN
Tel No 0116 267 7017
Mr B R Messore

There may be other suppliers of similar energy efficient equipment in the market. Please consult your supply directories or contact ETSU who may be able to provide you with more details.

"... the performance of the drives has been excellent with no failures or problems."

BEST PRACTICE PROGRAMME

ENERGY EFFICIENCY

Background

In the manufacture of furniture, large quantities of shavings, chippings and dust are produced which have to be removed. With few exceptions, waste removal is achieved by air extraction. Large quantities of air carry the waste to collection systems where the dust and chippings are separated by cyclones and/or dust bag extraction.

Although extraction systems are designed for maximum demand, few factories, even when working at maximum capacity, require all their machines to be operating continuously. When a factory is working on batch production there are times when machines are idle, for example due to machine setting or a specialised machine only being required for certain jobs. This inevitably means that air extraction does not need to run at full load for most of the time. Despite this, it is common practice for the extraction system to be switched on at the start of a shift and left running until the factory is closed.

As part of a programme to improve energy efficiency, Ducal decided to install frequency inverter variable speed drives (VSDs) to control their extraction system. This has the effect of reducing fan speed when some machines are idle and shutting fans down when no work is being carried out. As a result significant energy savings can be made.

Frequency Inverter Variable Speed Drives

A frequency inverter is an electronic device which converts the frequency of the mains electricity supply from 50 Hz to some other frequency determined by the user. This modified frequency, which can be varied, may be higher or lower than the mains supply.

As motor speed is proportional to the frequency of the supply, the motor can be controlled by varying the frequency. This is useful as the power consumption of the motor can be reduced by running it at a lower speed. In pump and fan applications, this aspect can be highly advantageous, as only a small reduction in speed can reduce the power consumption significantly.

A 20% reduction in speed results in a 50% reduction in power consumption.

Further information is available in Good Practice Guide No 2, 'Guidance Notes for Reducing Energy Consumption Costs of Electric Motor and Drive Systems'.

Extraction Groups

Variable speed drives were installed on extract fans serving the eight groups of machines at Ducal. Of these eight extraction groups, three were monitored.

Group 1

This extraction system serves a single high-volume CNC (computer numerical control)-controlled process line carrying out initial conversion of timber. Planks of sawn timber are cross-cut to length, multi-sawn into square sections followed by planing in a moulding machine. A single extract fan removes sawdust and chippings. Batch sizes tend to be large and any change-overs are relatively short. This activity is the nearest to a continuous process in the Ducal wood mill.

The inverter is controlled by monitoring the input conveyor and switching the extraction fan off whenever timber is absent for more than two minutes. Extraction requirements are almost constant.

Group 2

This extraction system services a lower capacity CNC cross-cut multi-ripping and planing machine and a CNC point-to-point borer. The machines are used for short batches with more frequent change-overs than the Group 1 installation. The inverter is controlled by monitoring the input conveyor to the cross-cut, switching the extraction fan off whenever timber is absent for more than two minutes. For the CNC borer, extraction is activated whenever the machine is switched on. The following table shows the switching logic.

CNC Cross Cut	CNC Borer	Fan
ON	ON	ON
OFF	ON	ON
ON	OFF	ON
OFF	OFF	OFF

Group 3

This extraction system serves one sanding and two dovetailing machines. The pattern of work is such that even with the factory fully loaded, one or more machines will be idle at any time. The dovetailers have low duty requirements and there are periods when no machines are operating and extraction is not required. This pattern is typical for most of the extraction units and offers the greatest potential for savings.

When a machine is working the inverter is switched on. If the sander is not operating, a damper closes off the extraction duct to reduce the extraction load. By isolating machines which are not operating, a lower flow rate is needed allowing greater savings to be made.

Moulding machine and extract ductwork

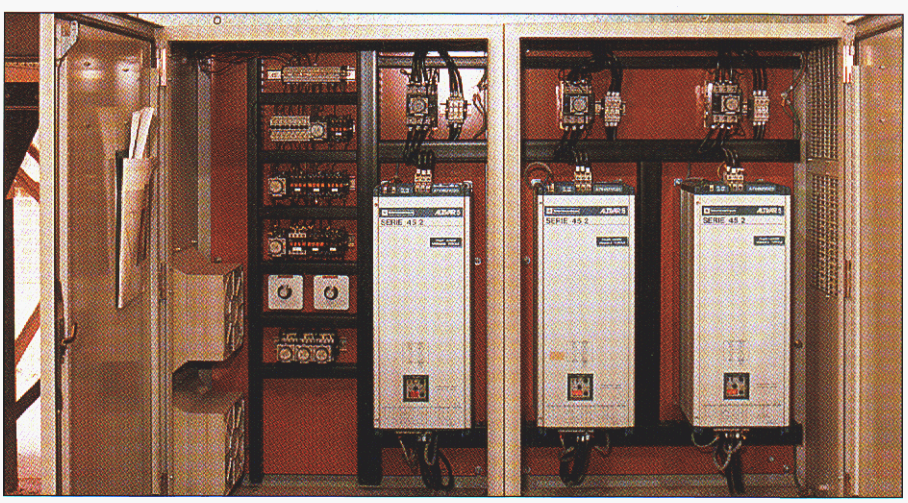
An additional manual switch is provided which allows the operator to limit extraction when small components are being sanded, by reducing the inverter frequency to 32 Hz.

Sander	Dove-tailer 1	Dove-tailer 2	Fan Speed
ON	ON	ON	FULL
ON	OFF	OFF	FULL
ON*	OFF	OFF	65%
ON*	ON	ON	65%
OFF	OFF	ON	70%
OFF	ON	OFF	70%
OFF	OFF	OFF	OFF

* Operator selects small component option

Installation and Commissioning

Ducal used their own engineering staff to design the inverter installation. Preliminary trials were conducted using an inverter loaned by the supplier. This confirmed the viability of using speed control and established that the maximum power could be reduced to 22 kW enabling less costly inverters to be selected.



Three 22 kW inverters

The original star/delta switch-gear was replaced by 22 kW variable frequency converters. The 36-inch fans, rated at 15,000 cubic metres per hour and with 30 kW motors, were retained. Sensors on the machines detect extraction requirements and relay them to the control panel. Simple logic patterns determine the fan speed required, and the inverters either vary the speed or switch the fan off as required.

Following the preliminary trials, each system has been arranged to operate at a maximum frequency of 48 Hz, giving some savings at all times.

The variable frequency inverters were mounted in standard enclosures with extractor fans for cooling. Installation and commissioning was straightforward, the eight VSDs being installed during weekend production breaks between November 1992 and March 1993. No significant problems were experienced.

Operating Experience

Since variable speed drives are solid-state electronic devices with no moving parts other than small cooling fans, they are inherently reliable and maintenance free. During the period from November 1992 to November 1993 the performance of the drives has been excellent with no failures or problems.

Optimum fan speed is easily programmed using the inverters, enabling accurate matching of air flow to extraction needs.

The lower fan speed and less arduous duty cycles have significantly reduced the fan noise within the factory and adjacent offices.

In addition, the reduction of air flow has improved safety during tool changes. Previously, the air cooled the operators hands and could cause loss of feeling.

Sanding master with dampers

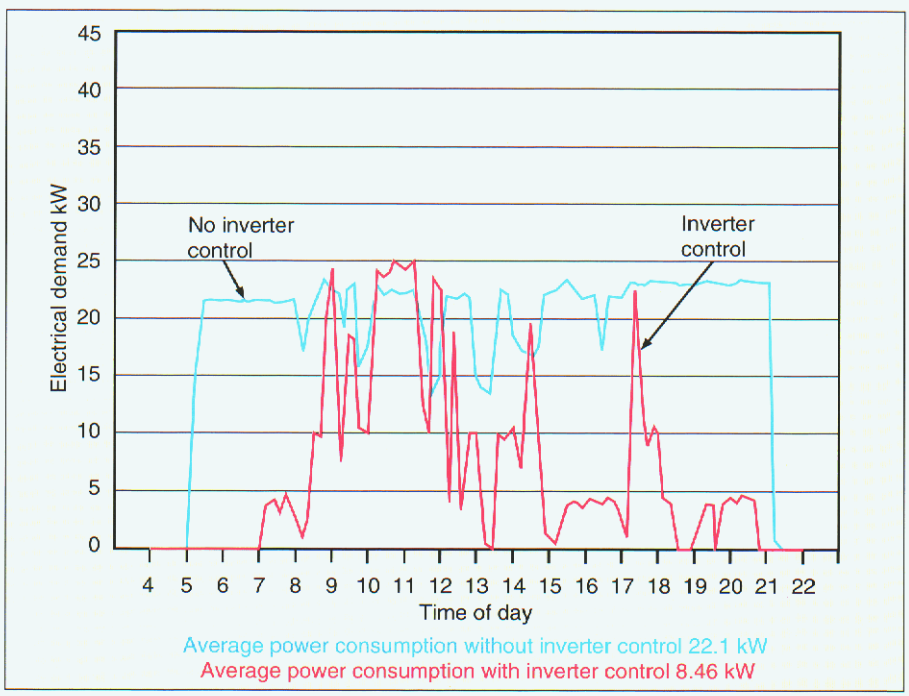
Energy Savings

Metering was carried out for periods of four to seven days, giving energy consumption data for each machine group over several shifts - with and without the inverters operating.

Significant savings were achieved in each group, even though the Ducal factory was fully loaded during the monitoring period and hence extraction rates were necessarily high.

- Group 1 - 36,400 kWh/year, equivalent to a reduction of 32%: Payback 1.7 years.
- Group 2 - 32,800 kWh/year, equivalent to a 39% saving: Payback 1.9 years.
- Group 3 - 49,600 kWh/year, equivalent to a 58% saving (see graph): Payback 1.3 years.

A combined saving for the three monitored groups of 118,000 kWh/year was achieved giving a 42% reduction in power consumption.



Power consumption for the Group 3 machines, with and without inverter control

Economic Analysis

The installation cost for the three monitored extraction groups at Ducal was £9,000. Annual energy savings of £5,800 were achieved, giving a simple payback period of 1.6 years.

The five extraction groups at Ducal which were not measured are considered to be most similar to Group 3. In this case it is estimated that for a total installation cost of £24,000 savings of £17,900/year would be achieved, giving a simple payback period of 1.3 years.

Measurements were made at a time when the Ducal factory was fully loaded with a backlog of orders and overtime being worked. Under more typical conditions there would be more idle time on machines and savings would be greater.

For installations where there are spare or little used machines, as is frequently the case in furniture manufacturing, savings of 50% can be expected from the installation of inverters. In cases like Group 1 machines, electronic soft start could offer a lower cost route to making savings.

At Ducal, extract air is filtered and recycled. On sites where air is not recycled an additional saving of £9,300/year would be achieved from a reduction in the space heating costs associated with all eight units, as less make-up air is required.

Future Potential

The installation of variable speed drives has demonstrated that substantial savings can be made by controlling fan speeds. Installation is simple, requiring modest electrical installation changes with no alterations to major plant. Once installed, speeds can be controlled or changed by simple re-setting.Capital costs are moderate enabling the investment to be recovered over a relatively short period.

Comments from Ducal Ltd

The extraction project is a major factor in achieving essential requirements within our manufacturing process. The removal of waste from our machinery has always been a troublesome and expensive challenge; it is totally inefficient and costly to use valuable energy to remove waste.

By the use of the inverter control, we have now reversed a negative overhead, in terms of wasted energy, into a positive situation, by using the saved energy in the productive process. Working conditions have improved, as noise levels and heat loss from the extraction plant have been substantially reduced, creating an even happier and more efficient working environment. Ducal are always receptive to new technologies, and we consider this particular innovation by Peter Appleton to be a winner in every way.

Ducal Ltd

Ducal Ltd

Ducal is one of Europe's largest manufacturers of solid wood furniture, with manufacturing bases in Andover, Hampshire, and in East London. It is also a market leader in design and innovation. Ducal have always treated environmental issues as a priority. Its timber is sourced in Scandinavia, and for each tree felled for production four fresh trees are planted.

Mr K Woods
Establishment Manager
Ducal Limited

Mr P Appleton
Senior Electrician

The Department of the Environment's Energy Efficiency Best Practice Programme provides impartial, authoritative information on energy efficiency techniques and technologies in industry and buildings. This information is disseminated through publications, videos and software, together with seminars, workshops and other events. Publications within the Best Practice Programme are shown opposite.

Further information:

For buildings-related topics contact:
Enquiries Bureau
BRECSU
Building Research Establishment
Garston, Watford, WD2 7JR
Tel 01923 664258
Fax 01923 664787
E-mail brecsuenq@bre.co.uk

For industrial and transport topics please contact:
Energy Efficiency Enquiries Bureau
ETSU
Harwell, Didcot, Oxfordshire,
OX11 0RA
Tel 01235 436747
Fax 01235 433066
E-mail etsuenq@aeat.co.uk

Energy Consumption Guides: compare energy use in specific processes, operations, plant and building types.

Good Practice: promotes proven energy efficient techniques through Guides and Case Studies.

New Practice: monitors first commercial applications of new energy efficient measures.

Future Practice: reports on joint R&D ventures into new energy efficiency measures.

General Information: describes concepts and approaches yet to be fully established as good practice.

Fuel Efficiency Booklets: give detailed information on specific technologies and techniques.

Energy Efficiency in Buildings: helps new energy managers understand the use and costs of heating, lighting etc.